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Optimized pulse shaping for trapped ion quantum computing[1]
T. ANDREW MANNING, SHANTANU DEBNATH, TAEYOUNG CHOI, CAROLINE FIGGATT, CHRIS MONROE, Joint Quantum Institute, University of Maryland Department of Physics and National Institute of Standards and Technology, College Park, Maryland 20742 — We perform entangling phase gates between pairs of qubits in a chain of trapped atomic ytterbium ions. Beat notes between frequency comb lines of a pulsed laser coherently drive Raman transitions that couple the hyperfine qubits to multiple collective transverse modes of motion [1]. By optimizing the phase and amplitude of segmented laser pulses, we demonstrate a five-segment scheme [2] to entangle two qubits with high fidelity over a range of detunings. We compare this special case of full control of spin-motion entanglement to a traditional single-segment gate. We extend this scheme to selectively entangle pairs of qubits in larger chains using individual optical addressing, where we couple to all the motional modes. We show how these robust gates can achieve high fidelities for practical gate times in an approach that scales realistically to much larger numbers of qubits.

[1] D. Hayes et al., Phys. Rev. Lett 104, 140501 (2010).
[2] S.-L. Zhu et al., Europhys. Lett., 73 (4), pp. 485-491 (2006)

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